



Why Space? Partnering with NASA for Out of this World Results

Paul Todd

SHOT, Inc. Greenville, IN, USA

“From rational drug design to microbial fermentation, from enhanced gene transfer to new biomedical materials, space is helping push biotechnology into new frontiers.”



SPEAKERS HAVE BEEN ASKED TO COVER

- **Effects of Space Flight on Microbial Antibiotic Production -- David Klaus, University of Colorado**
 - **Microgravity as a Preclinical Biomedical Test Bed -- Ted Bateman, Clemson University**
 - **Microgravity Crystallization of Protein Therapeutics -- Paul Reichert, Schering-Plough**
 - **Efficient Production of Biopharmaceuticals in Plants -- Richard Vierling, PNP, Inc.**
-

GRAVITY DEPENDENT PROCESSES



**Bubbles
Rising**



R. Brown, BioServe

**Bacteria
Metabolizing**



R. Kroes NASA

**Crystals
Growing**



R. Boltz, PSU

**Cells
Falling**



Plants Growing

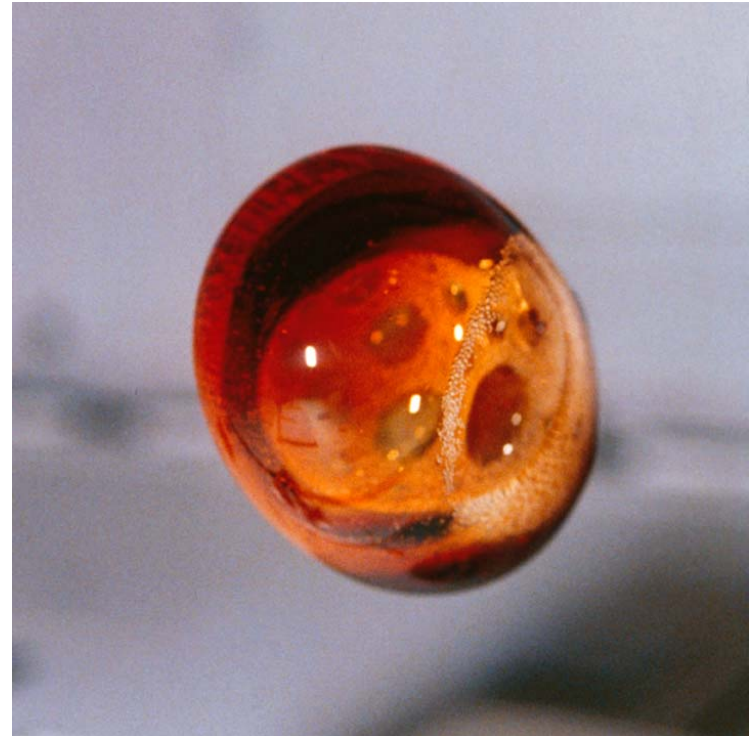


Humans Aging

WHAT HAPPENS IF $g = 0.0001$?

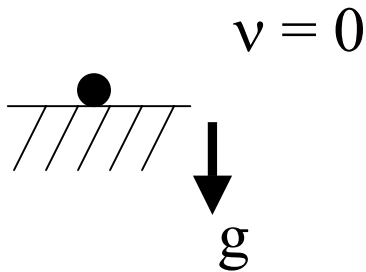
NO

- Sedimentation
(doesn't fall)
- Rayleigh convection
(bubbles don't rise)
- Hydrostatic pressure
(not fatter at bottom)
- Gravity counterforce
(not sitting)
- $Pe \rightarrow 0$



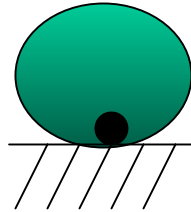
Responses to Gravity

Weight

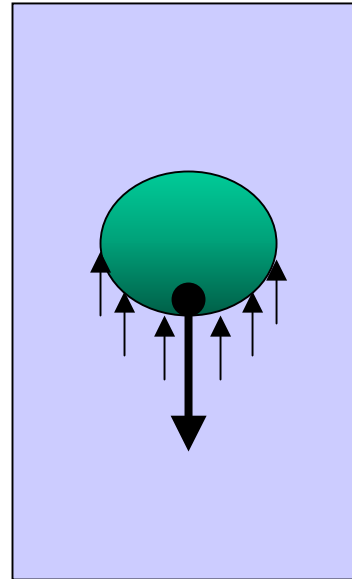


No motion

**Weight &
Deformation**



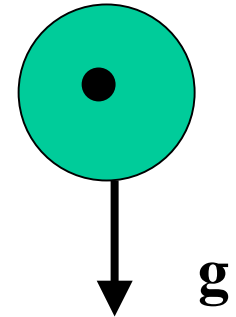
**Weight,
Deformation
and Motion**



$v = C$

**Terminal Velocity
i.e. no accelerated motion**

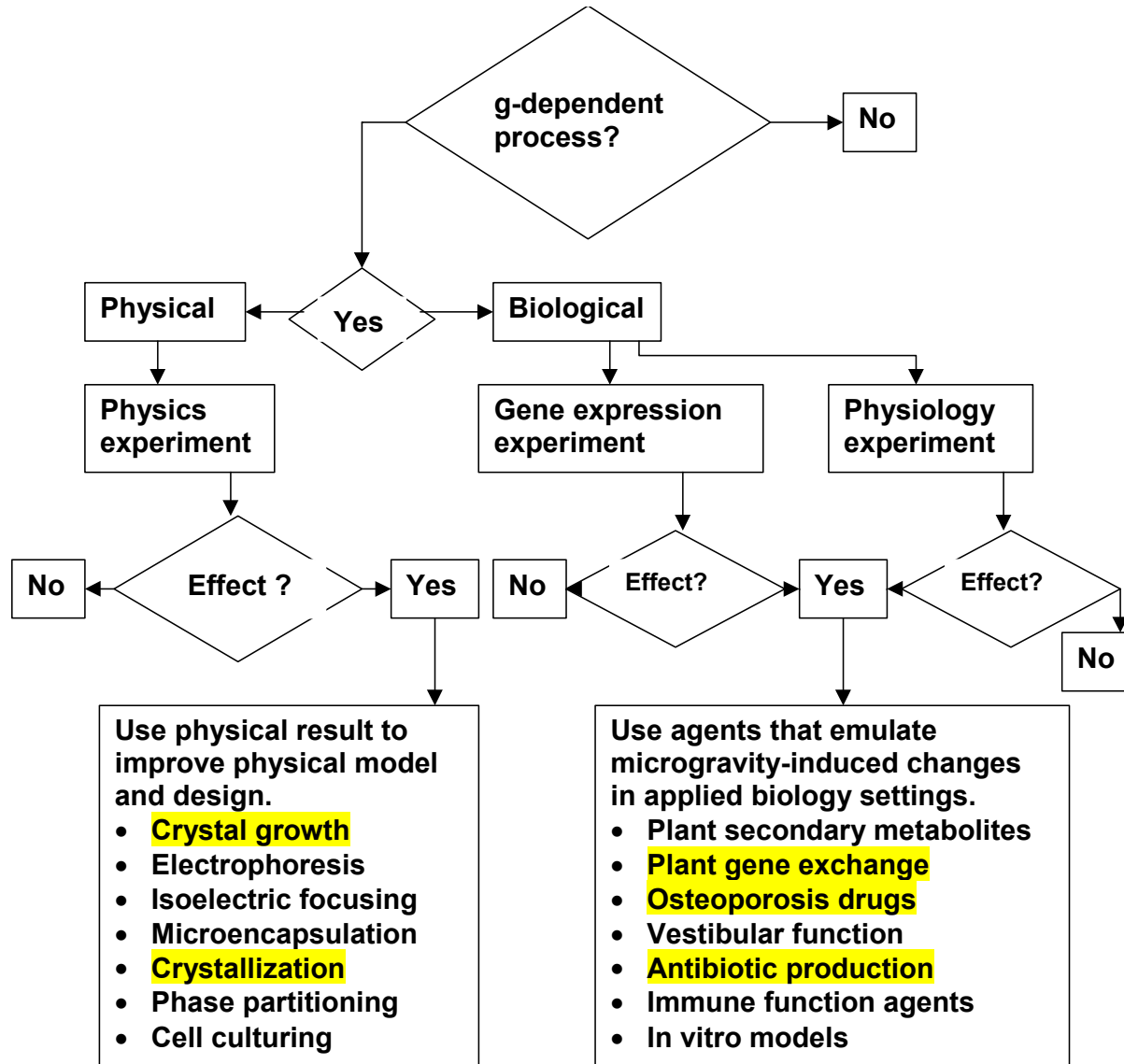
**Freefall, i.e.
no resistance**



**Weightless
Accelerated
Motion**

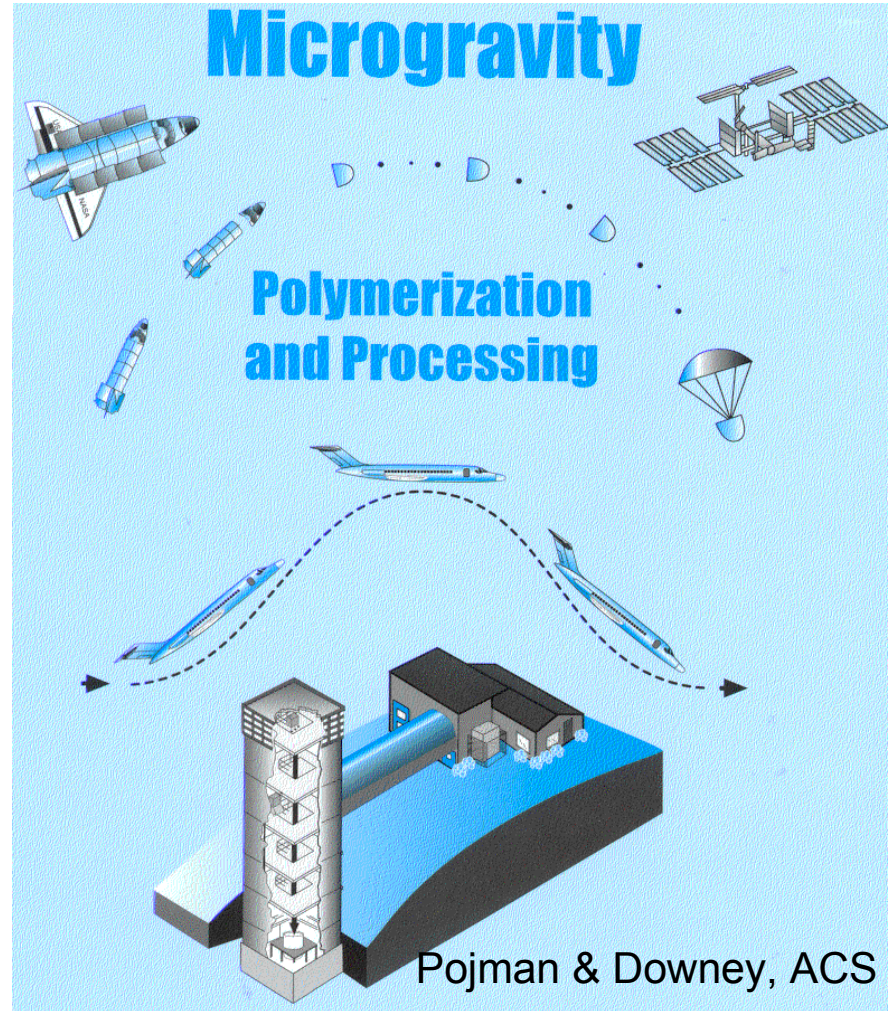
Courtesy D. Klaus, BioServe

DECIDING ON A LOW-GRAVITY EXPERIMENT

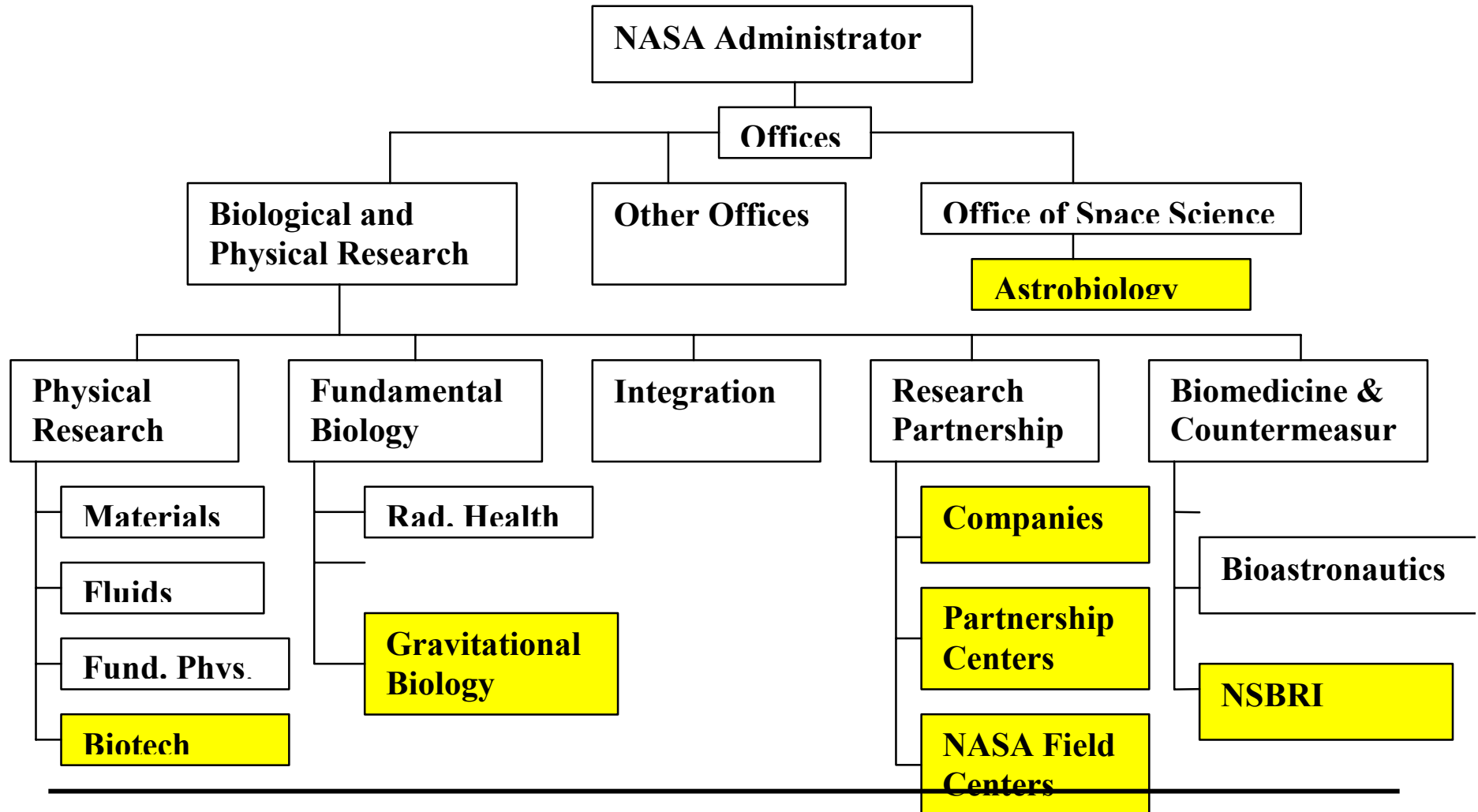


LOW-GRAVITY FACILITIES

- **Drop Towers (1-10 sec)**
- **Low-gravity aircraft (10-20 sec)**
- **Sounding Rockets (6-16 min)**
- **Space Shuttle (10-16 days)**
- **ISS (3-30 mo)**
- **Orbital Free Flyers (3-300 days)**



ACCESSING LOW GRAVITY THROUGH NASA





FACILITATORS OF COMMERCIAL USE OF LOW GRAVITY

NASA-SPONSORED RESEARCH PARTNERSHIP CENTERS

- **Bioserve Space Technologies, Univ. of Colorado**
- **Wisconsin Center for Space Robotics, Univ. of Wisconsin**
- **Center for Materials Development in Space, University of Alabama, Huntsville**
- **Center for Biophysical Science and Engineering, University of Alabama, Birmingham**
- **Center for Combustion Research in Space, Colorado School of Mines**

Corporate intellectual property is always protected.



FACILITATORS OF COMMERCIAL BIOTECHNOLOGY USE OF LOW GRAVITY

NASA FIELD CENTERS

- **Marshall Space Flight Center, Huntsville, AL**
- **Johnson Space Center, Houston, TX**
- **Ames Research Center, Mountain View, CA**
- **Glenn Research Center, Cleveland, OH**
- **Langley Research Center, Hampton, VA**
- **Stennis Space Center, MS**

Corporate intellectual property is protected.



FACILITATORS OF COMMERCIAL USE OF LOW GRAVITY

PRIVATE-SECTOR HARDWARE AND SERVICE PROVIDERS

- **Instrumentation Technology Associates, Exton, PA**
- **New Century Pharmaceuticals, Huntsville, AL**
- **Orbital Technology Corp., Madison, Wisconsin**
- **Paragon Space Development Corp., Tucson, AZ**
- **Payload Systems, Inc., Cambridge, MA**
- **Space Hardware Optimization Technology (SHOT), Greenville, IN**

Corporate intellectual property is protected.



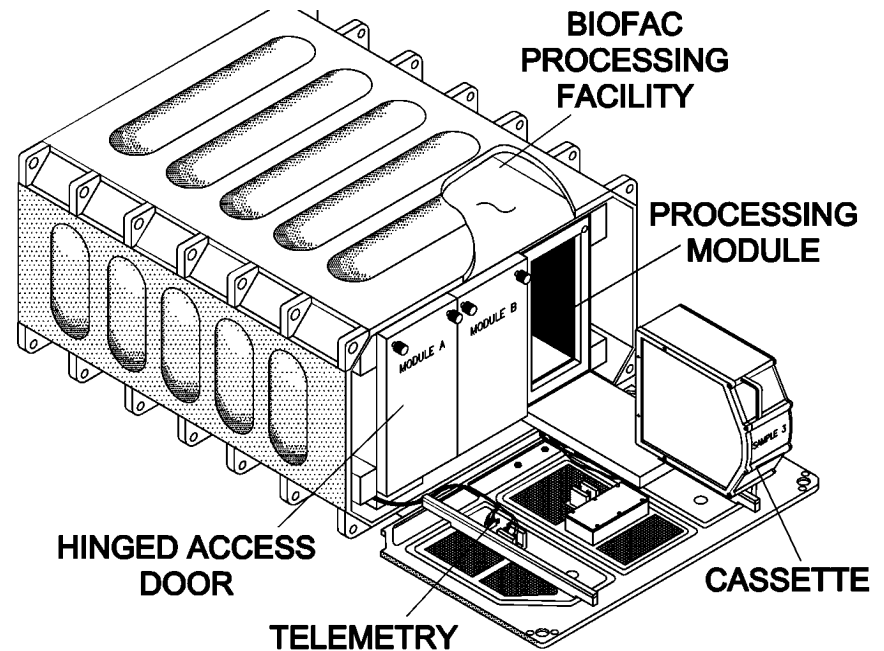
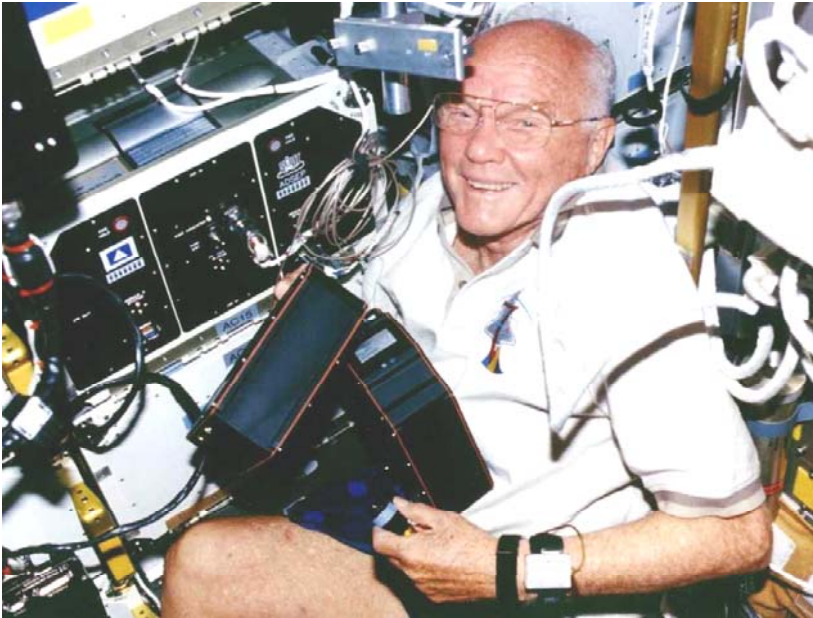
e Are



- Founded in 1988, Space Hardware Optimization Technology, Inc., (SHOT) is an applied-technology company providing engineering services and equipment to customers performing research both in space and in their ground-based laboratories.**



PROCESSING FACILITIES FOR SHOT CASSETTES



“ADSEP” 3-Cassette Processing Facility on STS-95



SPEAKERS HAVE BEEN ASKED TO COVER

- **Effects of Space Flight on Microbial Antibiotic Production -- David Klaus, University of Colorado**
 - **Microgravity as a Preclinical Biomedical Test Bed -- Ted Bateman, Clemson University**
 - **Microgravity Crystallization of Protein Therapeutics -- Paul Reichert, Schering-Plough**
 - **Efficient Production of Biopharmaceuticals in Plants -- Richard Vierling, PNP, Inc.**
-